OTPORNOST PREMA POŽARU NOSEĆE KONSTRUKCIJE OBJEKTA KOTLARNICA NA ČVRSTO GORIVO

DESIGN FIRE RESISTANCE OF BOILER ROOM BUILDING STRUCTURE FOR SOLID FUELS

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INTRODUCTION

One of the most commonly used methods for estimating the necessary fire resistance class for industrial building structures is defined in a group of German technical standards DIN 18230.
However, these standards have significant limitation and are not applicable to facilities in which energy is produced or distributed.
The aim of this paper is to extend the methodology defined in other paper in order to determine the necessary fire resistance of the building structure of a boiler room where solid fuels are used.
The proof of the adequacy of the class of fire resistance for building structure will be given independently using the Purt's methodology (according to the Euroalarm standard) while the obtained results will be verified by using the Gretener's methodology (according to the TRVB 100:2010 recommendations).
It should be noted that the method of separating the boiler room from fuel storage, as well as storage and transport of fuel from storage to the boiler room are not considered in the paper.

For the purpose of analysis the following fire prevention and protection measures are assumed:

1.1. Automatic fire alarm system is installed for boiler rooms with installed capacities larger than 500 kW or with areas larger than 150 m^2;

1.2. Constant presence of the person on duty next to the fire control panel for boiler rooms with installed capacities larger than 500 kW or with areas larger than 150 m^2;

1.3. Sufficient number of fire extinguishers before the arrival of the fire brigade;

1.4. Existence of appropriate fire hydrant installation for boiler rooms with installed capacities larger than 500 kW or with areas larger than 150 m^2;

1.5. Professional fire brigade located up to 5 km from the building;

1.6 Access to the boiler room is provided from three sides for the purpose of fire protection, i.e. there is at least one opening that can be used for fire protection purpose on every 20 m of the walls that border the fire sector for boiler rooms with installed capacities larger than 500 kW or with areas larger than 150 m^2;

Other assumptions include:

2.1. Mechanical ventilation system is applied, which provides adequate explosion protection, but without smoke and heat control system;

2.2. The boiler room is rectangular shape with single fire compartment, which is less than 40 m wide, and with an area of less than 3000 m^2 in which there are no other facilities;

2.3. The boiler room is located on the ground floor;

2.4. There are no other floors below and above the boiler room;

2.5. The building in which the boiler room is accommodated is free-standing or it is part of an industrial building;

2.6. No combustible materials are built into the boiler room construction;

2.7. Installed boiler heating duty is less than 1 GW;

2.8. No fuel is stored in the boiler room.

ANALYSIS - PURT’S METHOD

For the application of Purt’s method, nowadays widely accepted in form of European Fire Alarm Manufacturers Association (EUROALARM), it is necessary to determine two parameters: fire risk of the structure construction and fire risk of the structure contents.

The fire risk of the structure contents is a coefficient that qualitatively shows the harm to people and equipment. It is calculated using the equation:

$$R_s = H \cdot D \cdot F \qquad (1)$$

Where *H* is the harm to people coefficient, *D* is the harm to property coefficient and *F* is the smoke effectiveness coefficient.

In this case study, *H*=1 because there is no expected harm for people, and *F*=1 because there is no danger of smoke and corrosive gases.

If installed capacity of boiler is larger than 500 kW or boiler room area is larger than 150 m^2, *D*=2 because expensive equipment is installed in the boiler room and because interruption of the boiler operation causes stoppage of the supply of thermal energy to consumers.

Fire risk of the structure construction is a coefficient that qualitatively shows the hazard for the building construction and is calculated using the form:

$$R_0 = \frac{\left[\left(P_0 \cdot C\right) + P_k\right] \cdot B \cdot L \cdot S}{W \cdot R_i} \qquad (2)$$

From tables given in EUROALARM standard, P_0=1, because movable specific fire load Q_m =251 MJ/m^2 for boiler rooms and C=1.2 because the fire hazard class III (for solid fuels) is adopted.

Since no combustible materials are built in the construction of the fire sector in which the boiler room is accommodated, it follows that the fixed specific fire load is Q_i=0 thus P_k=0.

Coefficient L=1.1 since the nearest professional fire brigade is 5 km away.

If the width of the boiler room is less than 20 m, S=1, otherwise S=1.1. For the margin of safety in this paper the following values are adopted: S=1.1 and Ri=1.

Since the installation of an automatic fire extinguishing system is not a technically acceptable solution, it is necessary to choose the coefficient *W* so that R_0 <2 as follows:

$$\frac{1.45 \cdot B}{W} < 2, \quad (3) \quad \longrightarrow \quad 0.725 \cdot B < W \quad (4)$$

From equation it can be concluded than fire resistance of the building structure (*FR*) depends only on the area and height of the boiler room.

The previous condition is met when *W* =1, which is a case for all boiler rooms with area less than 10,000 m^2, from which it follows that it is sufficient to provide the supporting structure of the boiler room that is fire **resistant for 30 minutes**.

ANALYSIS - GRETENER'S METHOD

Based on the research of the Swiss engineer Gretener which were carried out in the period from 1961 to 1968, two methods for fire risk assessment were standardized:

(1) The Swiss Society of Engineers and Architects (SIA) published SIA81 method in 1981 and SIA2007 in 2007;

(2) The Austrian Fire Brigade Association published TRVB 100 Technical Recommendation in three versions issued in 1975, 1987 and 2010.

The decision on the necessary fire protection measures is made on the basis of the calculated value of the factor of preventive fire protection measures ($S_G \cdot F_G$) and the estimated value of the fire resistance of the building structure (F_G).

The following equation is used to determine the $S_G \cdot F_G$ factor:

$$S_G \cdot F_G = \frac{\left(G + 4.42\right) \cdot B_G}{6.25} \qquad (5)$$

In this case factor *G* is calculated according to the equation:

$$G = \frac{A \cdot b}{10^5} \qquad (6)$$

Where *A* is area of the fire sector [m^2] and *b* is width of the fire sector [m]. In this case the most unfavourable scenario is assumed: A = 3000 m^2 and b = 40 m when G = 1.2 it follows that

$$S_G \cdot F_G = 0.90 \cdot B_G \qquad (7)$$

where B_G is specific fire hazard factor calculated from the equation:

$$B_G = Q_G \cdot C_G \cdot R_G \cdot K_G \cdot A_G \cdot P_G \cdot E_G \cdot H_G \qquad (8)$$

where E_G is fire brigade intervention factor, A_G is the factor of fire activation, P_G is people harm factor, Q_G is specific fire load factor, C_G is factor of combustibility, R_G is smoke hazard factor, K_G is corrosion hazard factor and H_G is building height factor.

Based on the assumptions and recommendations from TRVB 100:2010, in this case Q_G = C_G = R_G = K_G = P_G = A_G = 1.

Factor H_G=1 because the boiler room is located on the ground floor and E_G=0.83 because the nearest professional fire brigade is 5 km away.

Therefore, in this case specific fire hazard factor can be calculated as:

$$B_G = 1.6 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 1 \cdot 0.83 \cdot 1 = 0.83 \qquad (9)$$

It follows that:

$$S_G \cdot F_G = 0.90 \cdot 0.83 = 0.75 \qquad (10)$$

From the results it can be concluded that it is sufficient to provide the supporting structure of the boiler room that is **fire resistant for 30 minutes**.

If boiler room is with installed capacity lower than 500 kW or with area smaller than 150 m^2, factor *G* can be calculated from equation (6).

In this case the most unfavourable scenario is assumed as A = 150 m^2 and b = 40 m when G = 0.06 it follows that

$$S_G \cdot F_G = 0.72 \cdot B_G \qquad (11)$$

Based on previous result from equation (9) B_G = 0.83 and equation (11) follows that:

$$S_G \cdot F_G = 0.72 \cdot 0.83 = 0.6 \qquad (12)$$

From the results it can be concluded that it is sufficient to provide the supporting structure of the boiler room that is fire resistant for 30 minutes, even in case where automatic fire alarm system is not installed in the boiler room.

CONCLUSION

In Central Europe the usual methodology for assessing the fire resistance of building structures of industrial facilities is given by the technical standard DIN18230: 2010 with limitations regarding the facilities in which energy is produced or distributed.

This paper presents one possibility for assessing the fire resistance of the building structure of a boiler room that accommodates boilers fired with solid fuels.

Two standardized procedures were used to assess fire risks.

The differences between the applied methods are that Purt's procedure does not consider the approaches of fire brigade engines and the probability of fire activation while Gretener's procedure does not consider the consequences of fires other than human losses.

Considering the initial assumptions from the results it can be concluded that for boiler rooms where solid fuels are used for generating energy it is sufficient to provide fire resistance of the building structure of 30 minutes.